English translation of
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ELECTROMECHANICAL PERMANENT-MAGNET BRUSHLESS MOTOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present utility model relates to an electromechanical permanent-magnet brushless motor, and pertains to a technical field of motor.

2. Description of the Related Art

Compared with a current motor outside which an inverter is separately installed, a permanent-magnet brushless motor inside which an inverter is installed has advantages that the motor is not interfered by lead wires, is less affected by a temperature, stagnant air, and bad working conditions, and is compact in configuration, reliable in operation, and convenient in adjustment and maintenance.

SUMMARY OF THE INVENTION

It is an object of the present utility model to provide an external rotor type motor which is compact in structure, reliable in operation, and strong in anti-interference, and which is capable of operating in various bad working conditions and being directly driven. The motor is applicable to an electrically operated wheel type motor for an electrically operated vehicle, and a washing machine drum type external rotor permanent-magnet brushless motor.

The utility model can achieve the following technical effects: 1. great moment, and a multiple pole configuration with a low cost, and 2. a configuration in which an inverter is inside a motor.

The operation principle of a motor according to the utility model is now explained by taking a brushless motor with 40 poles as an example. As shown in Figs. 1 and 2, reference numeral 1 indicates a core laminate sheet of an inner stator of a motor, reference numeral 2 indicates a core of an outer rotor, reference numeral 3 indicates permanent magnets (Nd-Fe-B), and reference numeral 4 indicates a lead wire for a stator winding. Twenty grooves are formed in the core of the outer rotor 2 of the motor, and the permanent magnets are disposed in the grooves so that N pole of the permanent magnets is directed

towards an axis of the motor. It is not necessary to separate the permanent magnets from adjacent projecting teeth (non salient poles) with nonmagnetic material. The permanent magnets are directly disposed in the core grooves formed by the adjacent projecting teeth to constitute a 40 pole motor. 36 grooves are formed in the sartor core and 36 windings are divided into three phases, each phase has 12 winding sets, each pole has three windings and the three windings are embedded in the windings grooves in an order of A, B, and C phases, respectively, so as to constitute a double layer bank winding. Since each pole of the stator has three windings, one winding is embedded in the winding grooves on both sides of each tooth, the intermediate winding of the three windings are reversely connected, and then the windings in each set of each phase are connected in series and lead wires are leaded out. For example, one winding is embedded in two adjacent grooves, that is, two sides of the same winding are fitted over one tooth. The windings of the A phase are embedded in grooves 1-4, grooves 10-13, grooves 19-22, and grooves 28-31, respectively, and an intermediate winding of every three windings are reversely embedded in the winding groove. The four groups of windings are connected in series with each other in an end to end manner to constitute lead wires for the A phase. The windings of the B phase are embedded in grooves 4-7, grooves 13-16, grooves 22-25, and grooves 31-34 in sequence, respectively, and the windings are connected in series with each other in an end to end manner to constitute lead wires for the B phase. The windings of the C phase are imbedded in grooves 7-10, grooves 16-19, grooves 25-28, and grooves 34-1 in sequence, respectively, and the windings are connected in series with each other in an end to end manner to constitute lead wires for the C phase.

The motor has 20 pairs of magnetic poles, the inner stator has 30 grooves, 20/18 of a pitch of the grooves is a pole pitch, and a phase pitch of the two adjacent phases is 20/3 of the pole pitch.

At a left side of the inner stator of the motor, an inverter power transistor assembly 13 and a heat-radiating plate 14 are mounted. Small magnet assemble 6, 7, 15 are mounted and fixed to a recess at a right end cover 16 of the motor so that N and S magnetic poles of small magnets constitute a circular shape and attached to a circular iron ring 6. After assembly, the assembly is embedded in a circular groove formed by non-magnetic material such as nylon and plastic and then fixed to the end cover of the motor. It is to be noted that a distribution of position and angle of the N and S poles of the small magnets is the same as that of inner poles of the motor. Hall elements 8 and a primary electronic switching circuit element 18 are assembled and then mounted in a groove box 10 of a nonmagnetic material and sealed with epoxy resin 9. Since the small magnet assembly and the Hall element assembly are fixed to the rotor and a stator shaft 5, respectively, there is relative motion between the small magnet assembly and the Hall element assembly so as to output a magnetoelectric inductive signal. The signal is introduced into a motor controlling field effect power transistor to drive a brushless motor to operate.

With the above solution, the motor and the inverter are integrated so that the motor has a compact structure, a decreased system volume, an improved reliability, and a strong resistibility to interference. In addition, the Hall element is not affected by an increased temperature inside the motor.

BRIEF DESCRIPTION OF THE DRAWINGS

The utility model will be further explained in conjunction with accompanying drawings and the embodiments.

Fig. 1 is a view showing a structure of a motor according to the present utility model.

Fig. 2 is a view showing a structure of multiple pole magnets and non salient pole projecting teeth of an outer rotor of the motor.

Fig. 3 is a view showing a structure of a small magnet assembly.

Fig. 4 is a view showing a combination of Hall elements.

Fig. 5 is a view showing a combination of a field effect power transistor and a heat-radiating plate.

Fig. 6 is a principle view of an inverter circuit.

In Fig. 1, 1 a stack member of motor silicon steel sheet, 2 a motor outer rotor housing, 3 permanent magnets, 4 motor windings, 6, 7, 15 a small magnet assembly, 8, 9, 10 a hall element assembly, 13, 14 field effect power transistor assemblies, 12, 16 motor outer rotor left and right end covers, and 17 a race of a needle roller bearing which is also used as a passage for a lead wire hole.

In Fig. 2, 1 a stator core and windings, 2 an outer rotor, 3 permanent magnets, 4 windings, and 5 a motor shaft.

In Fig. 3, 6 an iron ring, 7 a small magnet assembly, and 15 an annular groove of a nonmagnetic material.

In Fig. 4, 8 Hall elements, 9 an epoxy resin seal, and 10 a groove box of a nonmagnetic material.

In Fig. 5, 12 field effect power transistors, and 14 a heat-radiating plate.

In Fig. 6, 8 a Hall element circuit, 18 an electronic switching circuit, 19 a field effect transistor circuit, 20 a three-phase winding circuit and a protection circuit for a motor, 21 a protection circuit, and 22 a battery and a switching circuit.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to Fig. 1, an iron ring 6, small magnets 7 and an annular groove 15 is composed as a combination shown in Fig. 3. Assuming that a motor is one having 14 poles in this embodiment, 14

magnetic poles are distributed on an outer rotor core inside the motor. The small magnets 7 are equal in number to magnetic poles inside the motor and arranged so that position and angle of the magnetic poles of the small magnets are the same as angle and position of N and S poles of the permanent magnets inside the motor. A position of a same polarity of each magnet must be arranged so that after a polarity inside the motor is aligned with the same polarity of the small magnet 7, the small magnet is fixed to a groove of the right end cover 16 so that N and S polarities are directed towards outside of the groove. The annular groove 15 is molded with a nonmagnetic material such as nylon, bakelite, or ABS plastic. The iron ring 6 are firstly placed into the groove and then the small magnets are placed into the groove and onto the iron ring 6 to be arranged in a circular shape in sequence in a manner that N and S poles are adjacent to each other. As a result, a circular small magnetic pole ring is formed. This configuration compounds to replacement magnetic poles inside the motor with magnetic poles outside the motor so that Hall elements are not necessarily embedded in grooves for windings of the motor as the prior art, can be maintained without the motor disassembly, and no permanent magnetic material inside the motor will be demagnetized non-reversibly due to an excessive temperature of the motor and excessive current in the windings. Hall elements 8 and 9 in the assembly and an electronic switching circuit element 18 are combined and sealed in a circular groove box 10 of a nonmagnetic material. It is required that three Hall elements 8 are fixed to a bottom of the groove box at equal intervals based on an electrical angle of the motor having three phases and 14 poles. Then, the circular groove box is fastened to a motor shaft 5 with a gap required for a magnetic induction thereof with the small magnet assembly. A signal line and a power source line led out from the motor are penetrated into the motor through a groove hole in the motor shaft, and connected with the field effect power transistors and the power line. Another power line is penetrated into the motor through a lead wire hole particularly provided at an inner race 17 of a needle roller bearing at a left end cover 12 of the motor. Each of the right and left end covers are provided with a bearing cover for covering and protecting the bearings.

Figs. 5 and 6 are views showing a heat radiating plate assembly for a field effect power transistor and a circuit principle, respectively. The field effect transistors 12 as shown are selected according to rated voltage, rated power and rated current of the motor. The field effect transistors can adopt existing VMOS field effect transistor such as IRF type or RFM type field effect transistors. The heat radiating plate 14 is configured as shown in Fig. 5 and a plate of aluminium alloy is pressed, welded, shaped, and perforated, and assembled with the field effect transistors 12, and then the assembly of the heat-radiating plate 14 and the field-effect transistors 12 are fixed on a left side of the core of the stator of the motor. The Hall element can adopt a homemade switching type Hall element of CS3000 series or UGN3000 series. The Hall element is a combination of a Hall element and an integrated amplifying circuit. The electronic

switch 18 is provided with three AND gate CD4073 in a logical circuit and an inverter CD4049, both of which are CD4000 series chips. Out terminals of the power transistor 13 are connected in parallel to a protection circuit (a diode and a resistance connected thereto in series) 19 to prevent the power transistor 13 from being broken down by a back electromotive force. The windings of each phase of the motor are connected in parallel to a protection circuit 20 in which a diode and a resistance connected thereto in series. A system protecting circuit consists of LM311 to constitute a chopper constant current protection circuit 21 for making a voltage applied to the windings in starting has a period of time to increase by using RC time delay circuit in the LM311 circuit. Since the voltage applied to the windings has transition time, starting current rises in an exponential curve, thereby improving stability of starting of the motor. The LM311 circuit will output a low level to lock out all of the power switching elements to protect the field effect power transistors by using a principle of wave chopper constant current of the protection circuit 21 in the case where an accident occurs so that current of the circuit is excessive. In a power and switching circuit 22, a voltage of the power is determined according to requirement of the motor and a switch is selected depending on requirement of usage.

CLAIMS

What is claimed is:

1. An electromechanical permanent-magnet brushless motor pertain to a technical field of motor, comprising: a permanent magnet outer rotor, three phase winding inner stator, a magnetoelectric effect assembly, and a power transistor assembly, characterized in that:

a. the permanent magnet outer rotor is configured in such a manner that identical polarities of permanent magnets are arranged alternately so that adjacent core projecting teeth form polarities (non salient poles) opposite from those of the permanent magnets;

b. each pole of each phase of the three phase winding inner stator comprises three windings, the same winding is embedded in winding grooves on both sides of one tooth in a manner of double-layer bank winding, and three windings are forwardly and reversely connected in series and a lead wire is led out;

c. a power transistor heat radiating assembly 13, 14 is installed at a left side of the inner stator, a small magnet assembly 6, 7, 15 and a Hall element assembly 8, 9, 10, 16 are installed in a recess of a right end cover, a small cover is provided externally;

d. a needle roller bearing is installed in a left end cover 12, a lead wire hole is provided in a bearing inner race 17, and a mall cover is provided externally.

2. The electromechanical permanent-magnet brushless motor according to claim 1, characterized in that the outer rotor magnets include 20 magnets, the adjacent core projecting teeth include 20 teeth to form non salient poles, the permanent magnets are disposed so that N poles thereof is directed towards a center of a circle, while a pole of the adjacent projecting teeth is a S pole, there are 20 pairs of or 40 magnetic poles, and no magnetic shield material is interposed between the permanent magnets and the core projecting teeth.

3. The electromechanical permanent-magnet brushless motor according to claim 1, characterized in that the inner stator includes 36 grooves, and three-phase doubly-layer bank windings, and each phase includes 12 windings, and each pole includes 3 windings.

4. The electromechanical permanent-magnet brushless motor according to claim 1, characterized in that the power transistor heat radiating plate assembly installed at the left side of the inner stator is composed of 6 field effect power transistors 12 and a hear radiating aluminium 14 to constitute a three-phase inverter power output stage.

5. The electromechanical permanent-magnet brushless motor according to claim 1, characterized in that the small magnet assembly installed in the recess of the right end cover 16 of the motor outer rotor is composed of an iron ring 6, N and S pole magnetic ring7 and a groove ring 15 of nonmagnetic material.

6. The electromechanical permanent-magnet brushless motor according to claim 1, characterized in that on a shaft 5 at the recess of the fight end cover 16 of the outer rotor of the motor, Hall elements 8, epoxy seal material 9, a nonmagnetic material circular box 10 with a groove, and an electronic switching circuit element 18 for the Hall elements are fixed.

7. The small magnet assembly installed in the recess of the right end cover 16 of the motor outer rotor according to claim 5, characterized in that the small magnet assembly 7 is equal in number to magnetic poles inside the motor and arranged so that distribution of position and angle of N and S poles of the small magnet assembly is the same as that of angle and position of magnetic poles inside the motor.

8. The small magnet assembly installed in the recess of the right end cover 16 of the motor outer rotor according to claim 6, characterized in that a number of the Hall elements is equal to a phase number of the motor windings, a space between the respective elements is equal to an angle of phase difference of phase windings in the motor, and the Hall elements are attached to a bottom of a circular groove box 10 and fixedly installed on the shaft 5 of the motor, so as to keep a magnetoelectric induction signal output with the small magnets 7.

ABSTRACT OF DISCLOSURE

An electromechanical permanent-magnet brushless motor comprises permanent magnet salient poles on a rotor of the motor and core projection tooth non salient poles so that pole number and moment of the motor are increased, and cost of the motor is decreased, compared with a motor of the same size as the motor of the present application. In the motor of the present application, electronic inverter power transistors are directly installed in the motor. Small magnets and Hall elements moving relatively, electronic switches, protection circuit and the like are installed in a recess of an end cover of the motor so that the brushless motor needs only two DC lead wires, thereby integrate electronic and mechanical configuration. The present invention is advantage in that the motor is resistant to interference, is not affected by a temperature inside the motor, is compact in structure, and convenient in maintenance. The motor can be widely applied to electrically operated wheel type motors for electrically operated vehicles, and a super quiet directly driving motor for washing machine drum.

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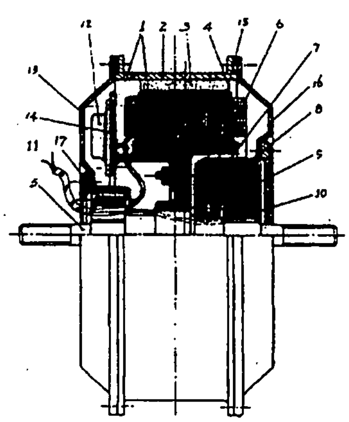
[54]实用新型名称 机电一体永磁无刷电机

[57]摘要

机电一体永磁无刷电机，它在电机转子上采用永磁体显极和铁芯凸齿隐极，使相同尺寸电机，极数增多，力矩加大，成本降低；该电机把电子逆变器功率管直接装入电机内部，在电机端盖凹入外部，装有小磁铁和相对运动的霍尔元件，电子开关、保护电路等，使该无刷电机只需二根直流引出线，达到机电一体化，其突出优点是抗干扰，不受电机内部温度影响，结构紧凑，维修方便，可广泛适用于各种电动车轮机电机，滚筒洗衣机超静直接驱动电机。



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权 利 要 求 书

1．一种机电一体永磁无刷电机，属于电机技术领域，它包括永磁体外转子，三相绕组内定子，磁电效应组件，功率管组件，其特征是：

a．永磁体外转子采用永磁体同极性相间布置，使相邻铁芯凸齿形成与永磁体相反的极性（隐极）；

b．三相绕组内定子，每相每极为三个线圈组，每齿两边的线槽中嵌入同一个线圈，双层叠绕，并使三个线圈正反串联引出；

c．内定子左侧安装功率管散热器组件13，14，右端盖凹入处安装小磁铁组件6、7、15和霍尔元件组件8、9、10、16，外设小挡盖；

d．电机左端盖12安装滚针轴承，轴承内滚道17设有引出线孔，外有小挡盖。

2．根据权利要求1所述的机电一体永磁无刷电机，其特征是：外转子永磁体有20块，相邻的铁芯凸齿也为20个齿，形成隐极，设永磁体为N极向着园心，则相邻凸齿为S极，共有20对40个磁极，永磁体与铁芯凸齿之间无隔磁材料。

3．根据权利要求1所述的机电一体永磁无刷电机，其特征是：内定子为36槽，三相双层叠绕组，每相12个线圈

组，每极三个线圈。

4．根据权利要求 1所述的机电一体永磁无刷电机，其特征是：内定子左侧安装的功率管散热板组件，由六只场效应功率管12和散热铝板14 组合构成三相逆变功率输出级。

5．根据权利要求 1所述的机电一体永磁无刷电机，其特征是：电机外转子右端盖16凹入处安装的小磁铁组件由铁圈6，N、S极磁环7和非磁性材料的槽圈15组合构成。

6．根据权利要求1所述的机电一体永磁无刷电机，其特征是：电机外转子右端盖16凹入处的轴5上，固定安装由霍尔元件8，环氧密封材料9，非磁性材料带槽元盒10 和霍尔元件的电子开关电路元件18组合构成。

7．根据权利要求5所述的电机外转子右端盖16凹入处安装的小磁铁组件，其特征是：小磁铁组件7的磁极数等于电机内部磁极数，并使得N、S极位置、角度分布等于电机内部磁极位置、角度分布。

8．根据权利要求6所述的电机转子右端盖16凹入处安装的霍尔元件8，其特征是；霍尔元件数等于电机绕组的相数，各元件之间相互间距等于电机内相绕组的相位差角度，并紧贴园槽盒10的底部固定安装在电机轴5上，保持与小磁铁7有磁电感应信号输出。

说　　　明　　　书

机电一体永磁无刷电机

本实用新型涉及一种机电一体永磁无刷电机，属于电机技术领域。

与目前把逆变器分装在电机外部相比，逆变器内装式永磁无刷电机具有不受引线干扰，对温度、污浊空气、恶劣工作条件影响小，结构紧凑，工作可靠性高，调节和维修方便。

本实用新型的目的是提供一种结构紧凑、工作可靠、抗干扰强，可工作在各种恶劣工况下直接驱动的外转子电机，适用于电动车的电动轮式电机和洗衣机滚筒式外转子无刷永磁电机。

本实用新型的目的是这样实现的：一、实现大力矩，低成本多极结构；二、实现逆变器内装方式。

一、下面以三相40 极永磁无刷电机为例说明其工作原理，如附图１、２所示，1电机内定子铁芯叠片；2 外转子铁芯；3永磁体（钕铁硼）；4定子绕组导线。 该电机外转子2的铁芯上开有20个槽，槽中安放永磁体，并使永磁体N极指向电机轴方向，永磁体与相邻凸齿（隐极） 之间无须用非磁性材料隔开； 是把永磁体直接安放在相邻的凸齿铁芯槽中，这样便构成40极电机。定子铁芯为36槽，36 只

线圈分为三相，每相12只线圈组、每极3只，分别按A、B、C三相顺序嵌入线槽中，构成双层叠绕。 由于定子每极都为三个线圈组，每个齿两边的线槽中嵌入一个线圈，并使三个线圈的中间一个线圈反接，然后分别将各相各组线圈串联引出。例如：相邻两槽嵌入一个线圈，即每齿套同一线圈的两条边，A相三个线圈分别嵌入1—4槽，10—13槽，19—22槽，28—31槽，并使每三个线圈的中间一个线圈反方向嵌入线槽中，把这样4组头尾相串联构成A相的引出线；顺次B相分别嵌入4—7，13—16，22—25，31—34槽；串联引出，其头尾构成B相；C相分别嵌入7—10，16—19，25— 28，34—1槽，串联引出，其头尾构成C相。

该电机为20对磁极，内定子36槽，槽距的20/18为极距，相邻两相的相距为20/3极矩。

二、 在电机内定子左侧安装逆变器功率管组件13 和散热板14，电机右侧端盖16凹入处，安装小磁铁组件6、7、15，把它固定在端盖16凹入处，并使小磁铁的N、S 磁极组成园形，粘紧在园铁环6上，组合后嵌入园形非磁性材料如尼绒、塑料园槽中，再固定在电机端盖中，必须使得小磁铁N、S极位置、角度分布与电机内部磁极位置、角度相同。霍尔元件8及前级电子开关电路元件18组合后，装入非磁性材料槽盒10中，并用环氧树脂9密封，由于小磁铁组件与霍尔元件组件是分别固定在转子和定子轴5上，两者有相对运动和磁电感应信号输出，把该信号引入电机控制场效应功率管，再驱动无刷电机运转。

由于采用上述方案，可使电机与逆变器组合为一体，达到结构紧凑、系统体积缩小，可靠性提高，抗干扰强，霍尔元件不受电机内部温升的影响等。

下面结合附图和实施例对本实用新型进一步说明。

图１是本实用新型的电机结构图。

图２是电机外转子多极永磁体与隐极凸齿结构图。

图３是小磁铁组件结构图。

图４是霍尔元件组合图。

图５是场效应功率管与散热板组合图。

图６是逆变器电路原理图。

图１，1电机硅钢片叠件, 2电机外转子壳本, 3永磁体, 4电机绕组, 6、7、15小磁铁组件, 8、9、10霍尔元件组件, 13、14场效应功率管组件，12、16电机外转子的左、右端盖，17滚针轴承内滚道, 同时兼作引出线孔的通道。

图２中，1定子铁芯和绕组, 2外转子, 3永磁体, 4绕组, 5电机轴。

图３中，6铁环, 7小磁铁组件, 15 非磁性材料的园环槽。

图４中，8霍尔元件, 9环氧树脂密封件, 10 非磁性材料槽盒。

图５中，12场效应功率管, 14散热板。

图６中，8霍尔元件电路, 18电子开关电路, 19场效应管电路, 20电机三相绕组电路及保护电路, 21保护电路, 22电池及开关电路。

在图1中，铁环6，小磁铁7和园环槽15是按图3组合构成，若设该实施例电机为14极，则在电机内部外转子铁芯上分布有14个磁极，小磁铁7是与电机内部磁极数相等，并且是根据电机内永磁体N、S 磁极相等的角度位置来分布，各块磁铁的同极性位置，必须是电机内部极性与小磁铁7的同极性对准后再固定在右端盖16凹槽中，使N、S 极性向着凹槽外部，15园环槽是用非磁性材料如尼绒，胶木，或ABS塑料模压成形，槽中先放入铁环 6，再放入小磁体，并按顺序N、S相邻排列成园形，放在铁环上，组成园形小磁极环。这样做相当于把该电机内部磁极移到了电机外部，目的是使霍尔元件不必与现有技术哪样嵌放在电机绕组槽口，并且可以使得维修时不必折开电机，也不会受到因电机过高温度和线圈过大电流使得电机内永磁材料产生不可逆退磁的影响。霍尔元件8和组件中的9，及电子开关电路元件18，都组合固封在非磁性园形槽合10中，要求三个霍尔元件8按三相14极电机的电角度等距离固定在槽合底部，再把园形槽合紧固在电机轴5上，并保持与小磁铁组件有磁电感应所必须的间隙，引出信号线和电源线从电机轴上的槽孔穿入电机内部，并与场效应功率管和电源线联接，电源线是从电机左端盖12的滚针轴承特设的内滚道17引线孔中穿入，电机左右端盖均设有轴承盖，起到复盖和保护作用。

图5和图6分别为场效应功率管的散热板组件和电路原理图。图中场效应管12是根据电机使用的额定电压、

额定功率和额定电流大小来选用，可以选用现有的 VMOS 场效管如IRF型或RFM型；散热板14其结构如图５所示，选用铝合金板冲压成形后焊接、整形和开孔与12 组装后固定在电机定子铁芯的左侧。霍尔元件可选用国产CS3000系列或UGN3000系列的开关型，它是霍尔元件和放大集成电路的组合；电子开关18是由逻辑电路中的三个与门CD4073和反相器CD4049提供，这些元件均为CD4000系列芯片；功率管13输出端并联防止反电势击穿的保护电路(二极管与串联电阻)19；电机绕组每相线圈均并联二极管与电阻串联的保护电路20；系统保护电路由LM311 组成斩波恒流保护电路21；其作用是利用LM311电路中的RC延时电路，使启动时加到绕组上的电压有一上升过程，由于加到线圈绕组上的电压有一个过渡过程，启动电流按指数曲线上升，这就能提高电机启动的稳定性，利用保护电路21中斩波恒流原理，当出现意外情况使电路电流过大时，LM311将输出低电平封锁全部功率开关元件，保护场效应功率管；电源及开关电路22中，电源电压是根据电机要求来确定其电压高低，开关按使用要求选用。

说　明　书　附　图

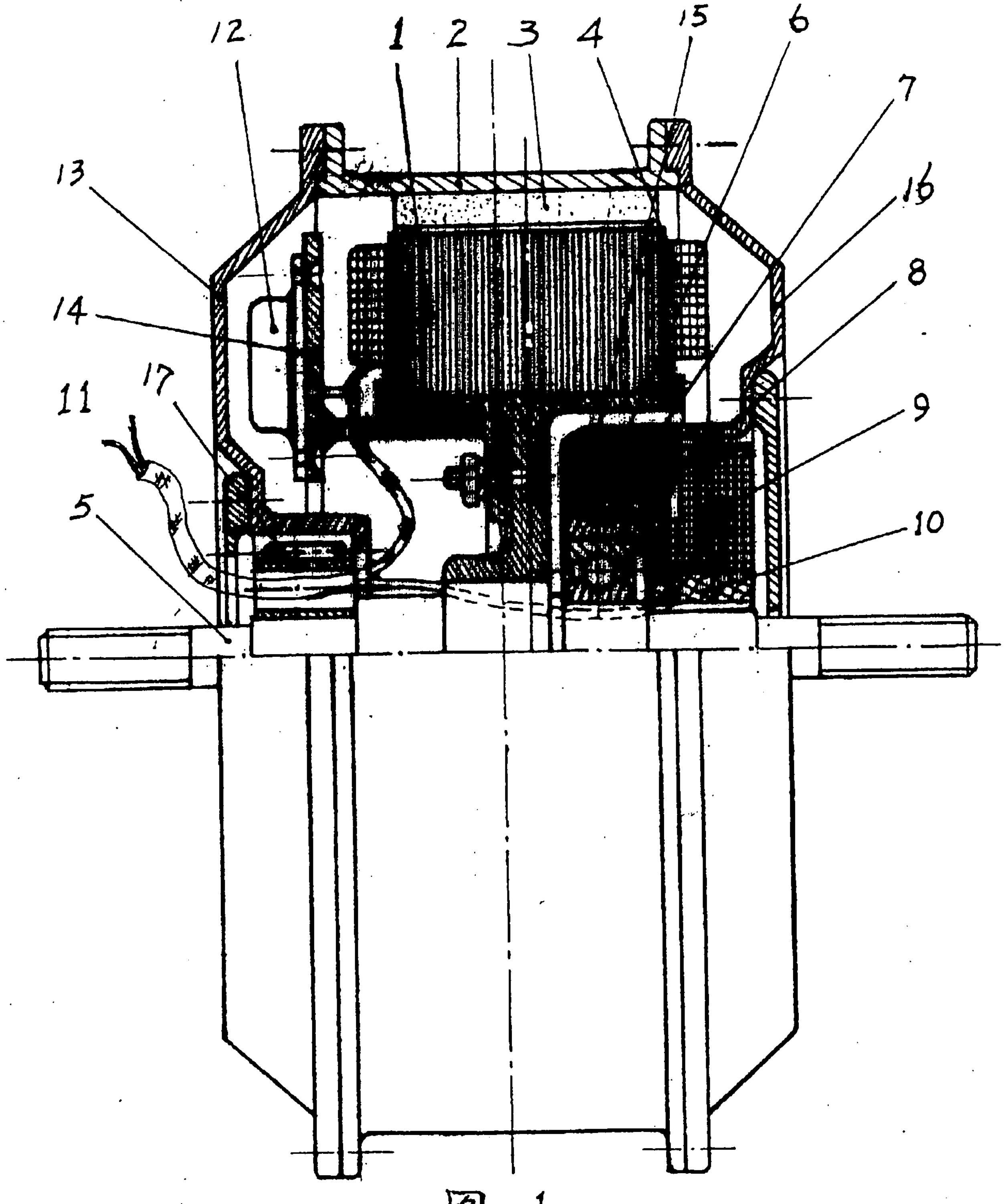

图 1

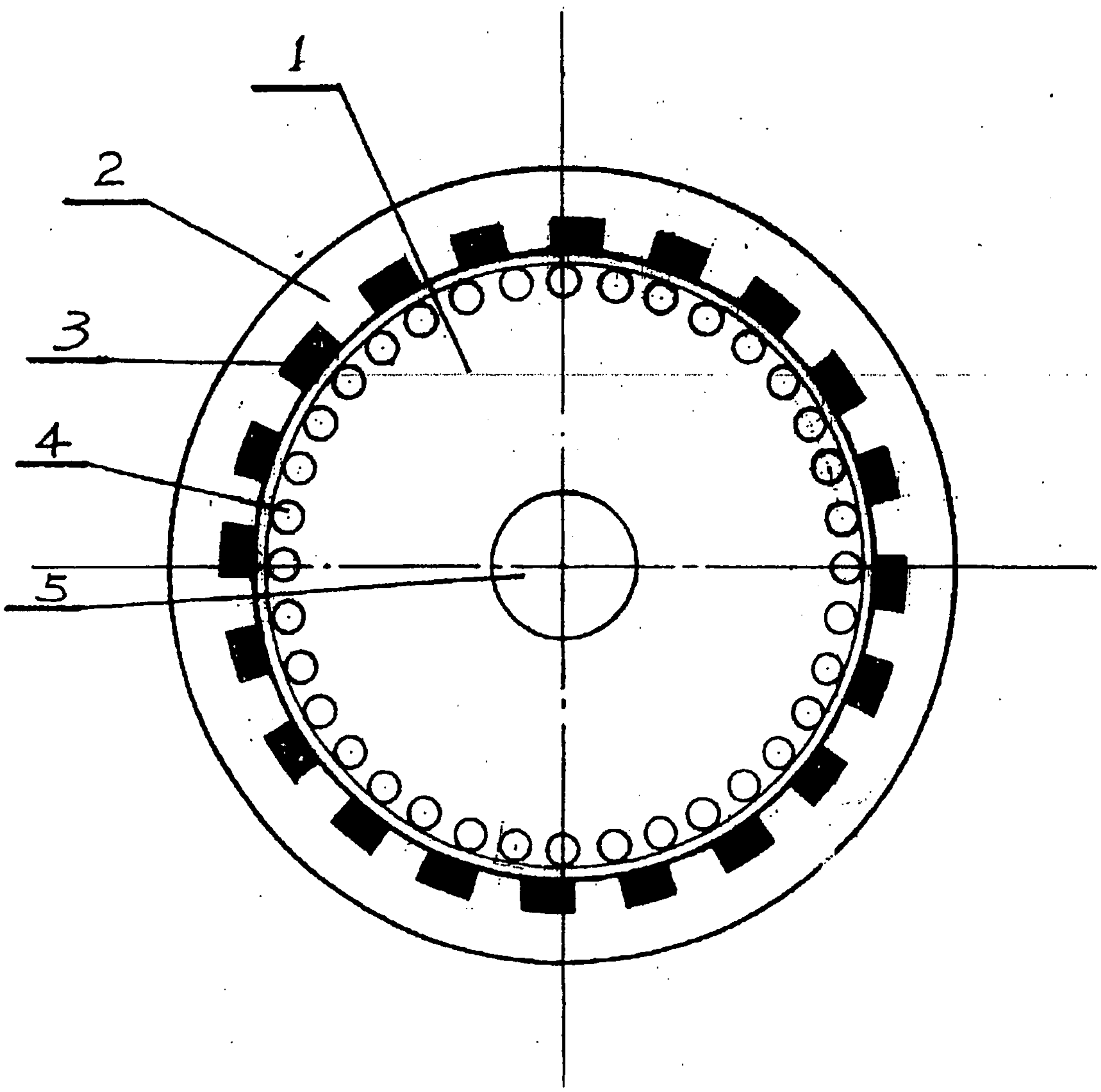

图 2

11.05

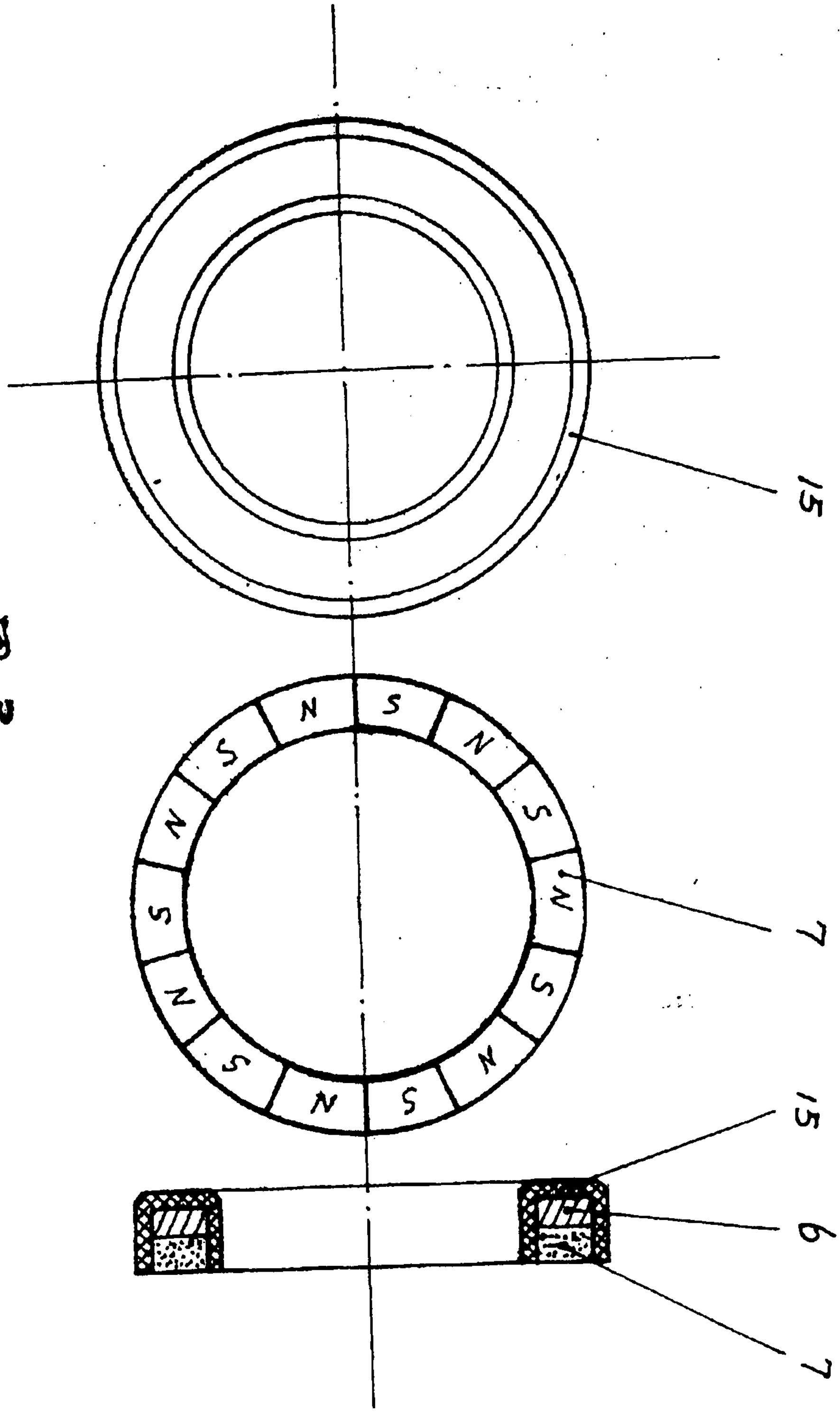

図 3

98.11.05

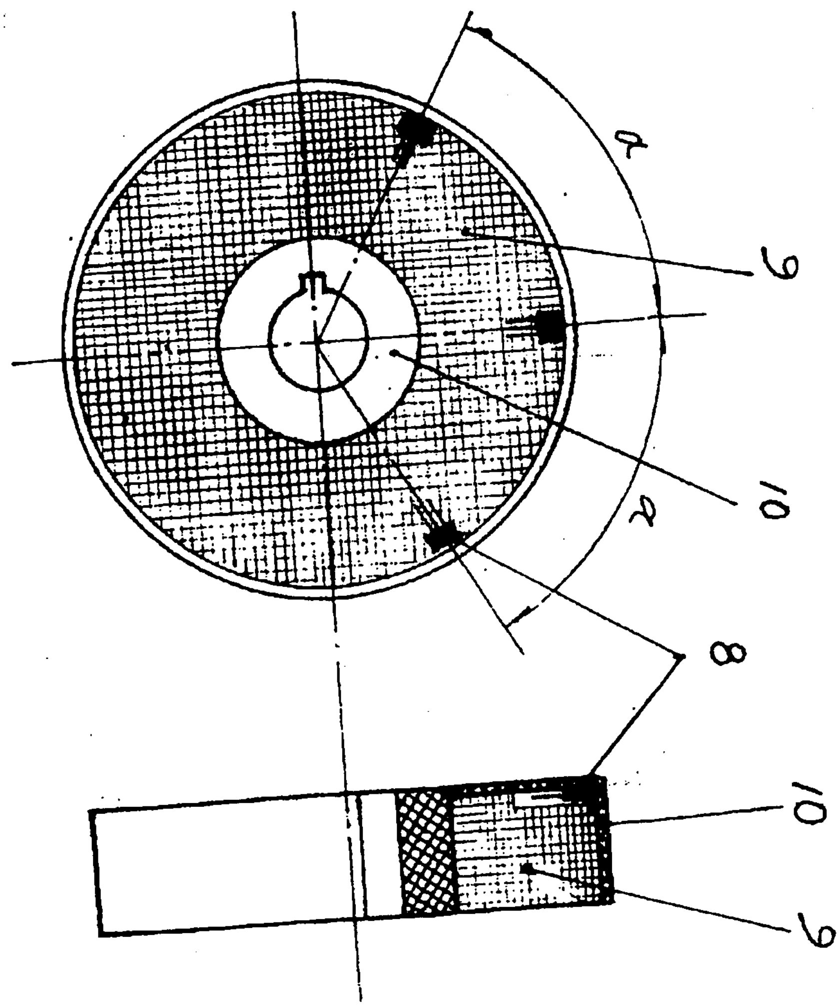

图 4

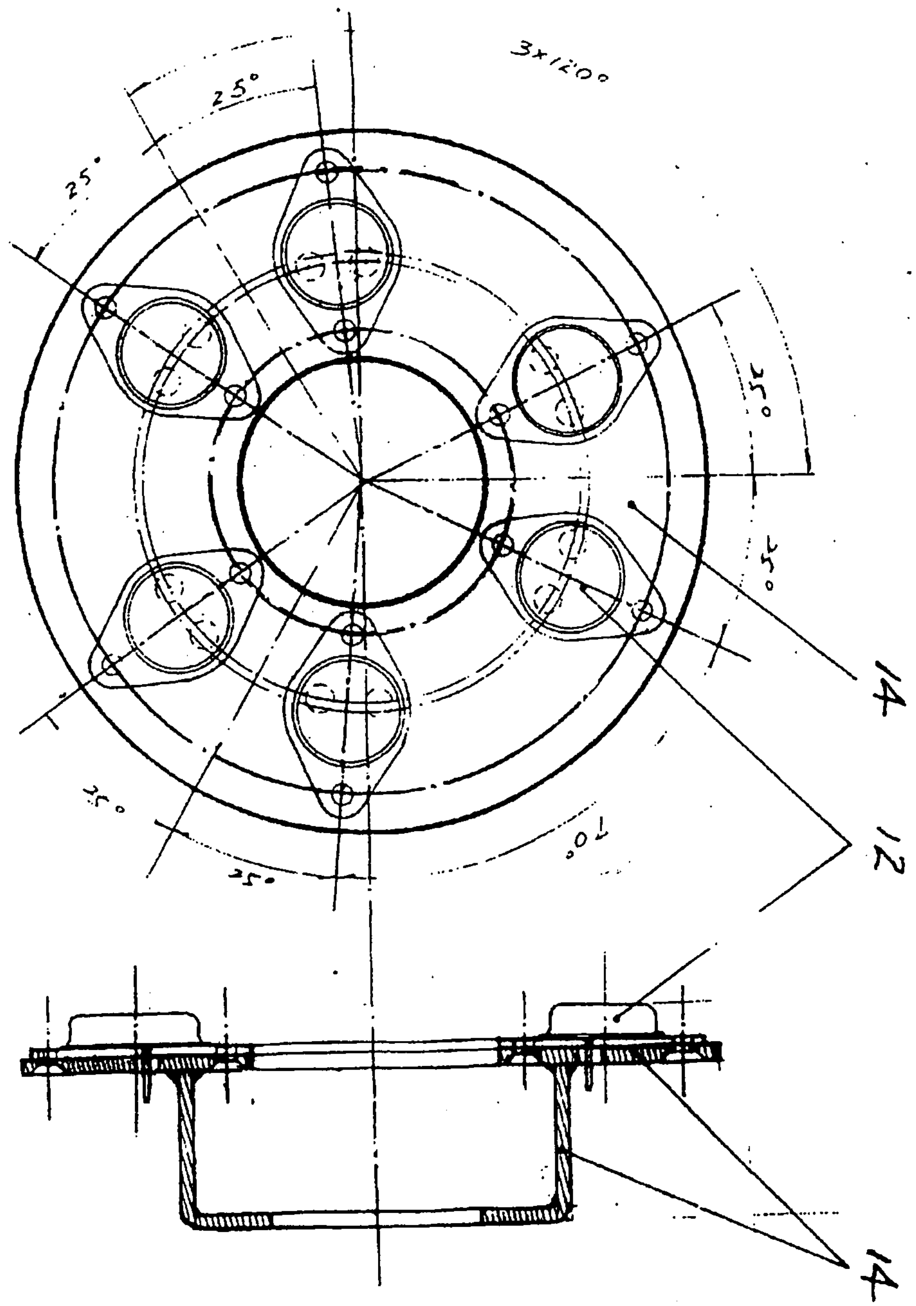

図5

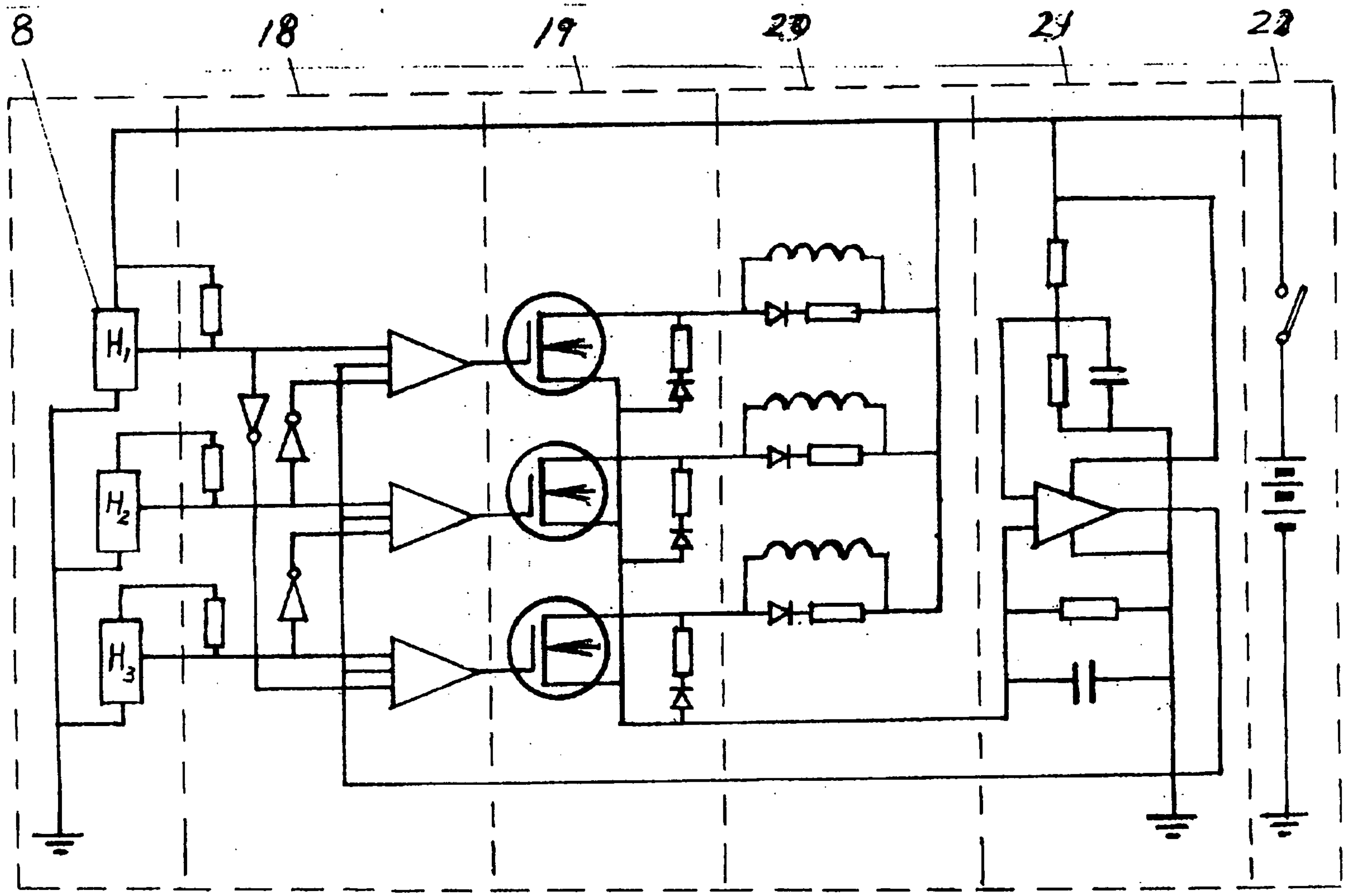

图 6